3. MISSION PHASES

This section provides an overview of the mission phases for TRMM. First, the Pre-launch Planning and Testing phase is described with respect to the spacecraft and GDS. After testing, a description of Launch operations is provided. In the Launch overview section a brief description of the launch vehicle, TRMM launch configuration, and L&IOC phase are also provided. A brief description of the L&IOC phase has been included, however details will be provided in a separate Launch and In Orbit Checkout Plan. In this section, detailed timelines are provided to describe spacecraft and instrument checkout activity to be performed during this period of the mission. After Launch Operations, a brief description of Normal Mission operations is provided. Finally, a description of the EOL Ocean Disposal phase of the mission is provided.

3.1 PRE-LAUNCH PLANNING AND TESTING

The Pre-launch Planning and Testing phase of the mission extends from the initial deliveries of ground segment software and the start of spacecraft I&T activities through launch. This phase involves more than spacecraft testing alone. Element software and integrated system checkout, and Mission Readiness Testing (MRT) must also be performed.

In addition, supporting elements will conduct internal testing and checkout separate from any interface testing required of the TRMM GDS.

3.1.1 Spacecraft Testing with the TRMM Ground Data System

The primary test opportunities are those which involve the spacecraft. The Project has allocated five tests while TRMM is being integrated in the Building 7/10 facility. These opportunities are for Code 500 test and familiarization as the FOT and all supporting elements exercise their operational hardware, software, and procedures with the spacecraft. The five tests consist of a Hard-line Data Flow to supporting ground elements at GSFC, an End-to-End data flow utilizing the Space Network (SN) and the ground system via a RF link, two Mission Simulations to exercise operational procedures and scenarios, and a test to verify the end-to-end interface between the STTF, MOC, and the spacecraft for table and memory load/dump operations.

Testing while the spacecraft is at the Yoshinobu Launch Complex (YLC), TnSC, consists of three interface tests including a Hard-line data flow, an End-to-End data flow utilizing the TDRS SN, followed by a Launch Countdown Rehearsal with participation by all ground system elements. I&T personnel will ensure a proper spacecraft configuration and interface for spacecraft tests at the launch site. They will also monitor TRMM during all test periods and will assume control of the spacecraft as situations warrant. Reference the TRMM Observatory to MOC Interface Test Plan, October 1994 (TRMM-500-190) for a more detailed description of all test objectives and approximate dates.

3.1.2 Ground Data System Element Testing

Ground Data System (GDS) element testing for TRMM includes testing of all ground system entities required to support the mission. Individual elements will perform internal testing to verify their own system capabilities. Element testing may entail interface checkouts with other elements, as well as high-visibility participation in spacecraft tests. An important factor in element preparation is the service provided by the TTTS. This medium fidelity system is expected to be helpful in refining operational procedures and activities, in addition to the initial checkout of the telemetry and command interface with the MOC.

3.1.3 TRMM Test & Training Simulator

The TTTS is a medium fidelity simulator which will emulate spacecraft subsystem functions. Initial MOC interface testing will be performed with the TTTS as the FOT prepares for the first interface test with the TRMM spacecraft. The FOT expects to use this simulator throughout the pre-launch period to test and verify procedures, page definitions, the operational data base, MOC data processing, command uplink, operational scenarios, and for general FOT training. In addition, the TTTS will also be used with the RF SOC, out of Building 25, for interface checkouts with the SN prior to all spacecraft End-to-End tests (with the SN).

3.1.4 Software Test and Training Facility

Another important part of element testing is the interface with the Software Test and Training Facility (STTF). The STTF will provide a high-fidelity means to monitor critical subsystem operations of the ACS, ACE, and FDS. Areas such as orbit and attitude maneuvers, processor and bus configurations, processor restarts, table loading/dumping, and filter table and recorder management can be simulated using the simulator capabilities of this facility. This simulation capability will be of great benefit for FOT training, routine procedure definition, and exercising anomaly detection and corrective action.

3.1.5 Software Testing

Software testing involves verification of MOC software as deliveries are made. Core MOC capabilities include real-time data processing, off-line processing, and mission planning. This testing serves as a MOC-internal test and acceptance function before the software is released for operations. Primary test responsibilities lie with members of the CMOS test teams. An additional facet of software testing is FOT participation during acceptance testing. The FOT uses this time to become familiar with new releases and assists in problem identification and correction. In this way, a smoother transition of the software to an operational status is expected.

3.1.6 Systems Testing

In addition to MOC software testing, systems testing provides the FOT with the knowledge of those peripheral systems necessary for mission operations. These systems, which are in addition to the central MOC software, include the following:

a. Generic Trend Analysis System (GTAS)
b. User Planning System (UPS)
c. Generic Spacecraft Analyst Assistant (GenSAA)
d. Mission Operations Planning and Scheduling System (MOPSS)
e. Real-Time Attitude Display (RTADS) and the Heads-Up Display (HUD)
f. Guide-Star Occultation (GSOC) Utility {for CERES planning aid generation}

The above systems are tested as they become officially available, but also during the System and Acceptance test phases. Once an understanding is achieved, the FOT incorporates these systems in operational procedures.

3.1.7 Mission Readiness Testing

Another series of tests validates the operational readiness of the TRMM GDS to the Implementation Manager (IM). The Mission Readiness Manager (MRM) ensures that all DMR-2 requirements are met and the ground system can properly support the mission.

To accomplish this task, the MRM requires a series of nine distinct tests to validate all TRMM requirements. Test dates are coordinated with the existing spacecraft test schedule. It is possible that MRT testing could run in conjunction with other test efforts. The MRM chairs a test team meeting which pulls together all ground system elements for the purpose of finalizing test activity, results, and correction of existing problems. MRM testing should be completed by the time the spacecraft is shipped to the launch site.

The MRM will conduct interface checkouts with pertinent elements of GDS I&T, STTF, and the TTTS prior to the spacecraft tests. In addition, the MRM will also ensure an interface with the launch site.

3.2 LAUNCH AND IN ORBIT CHECKOUT

The following sections provide a description of spacecraft and ground system operations during the L&IOC phase. The L&IOC phase of the mission begins at liftoff, through separation from the H-II, and extends until all instruments are powered ON and collecting science data (approximately 30 - 45 days). The following L&IOC scenario describes the current spacecraft hardware/software launch configuration, discusses launch/separation events from the H-II launch vehicle, and highlights expected operations during the L&IOC phase. A more detailed account of the entire L&IOC phase (i.e., spanning Launch + 30 to 45 days) will be documented in a separate TRMM Launch and In Orbit Checkout Plan.

3.2.1 Launch

Launch of the TRMM spacecraft is scheduled for November 1997 (with an exact date to be negotiated between NASA and NASDA), from the YLC. The seasonal launch period for the mission is set by NASDA, and is approximately 30 to 45 days. At launch, the TRMM spacecraft will be placed into a circular orbit at an altitude of 380 ± 10 km, with an inclination of 35° ± 0.1°. The means to achieve this operational orbit will be a NASDA H-II expendable launch vehicle (ELV).

3.2.1.1 Launch Vehicle Overview

The H-II is a two stage rocket equipped with two solid rocket boosters. The first and second stages use liquid Oxygen/liquid Hydrogen (LOX/LH_2) as propellant. The H-II has a length of 49 meters, and a diameter of 4 meters. The two piece fairing consists of a honeycomb sandwich structure with a ribless internal surface. TRMM is scheduled onboard the sixth planned flight of the H-II. TRMM will be launched with a companion payload, namely the NASDA Engineering Test Satellite (ETS-VII). TRMM will be the top payload (first to be deployed).

Figure 3.2-1 depicts the H-II launch vehicle.

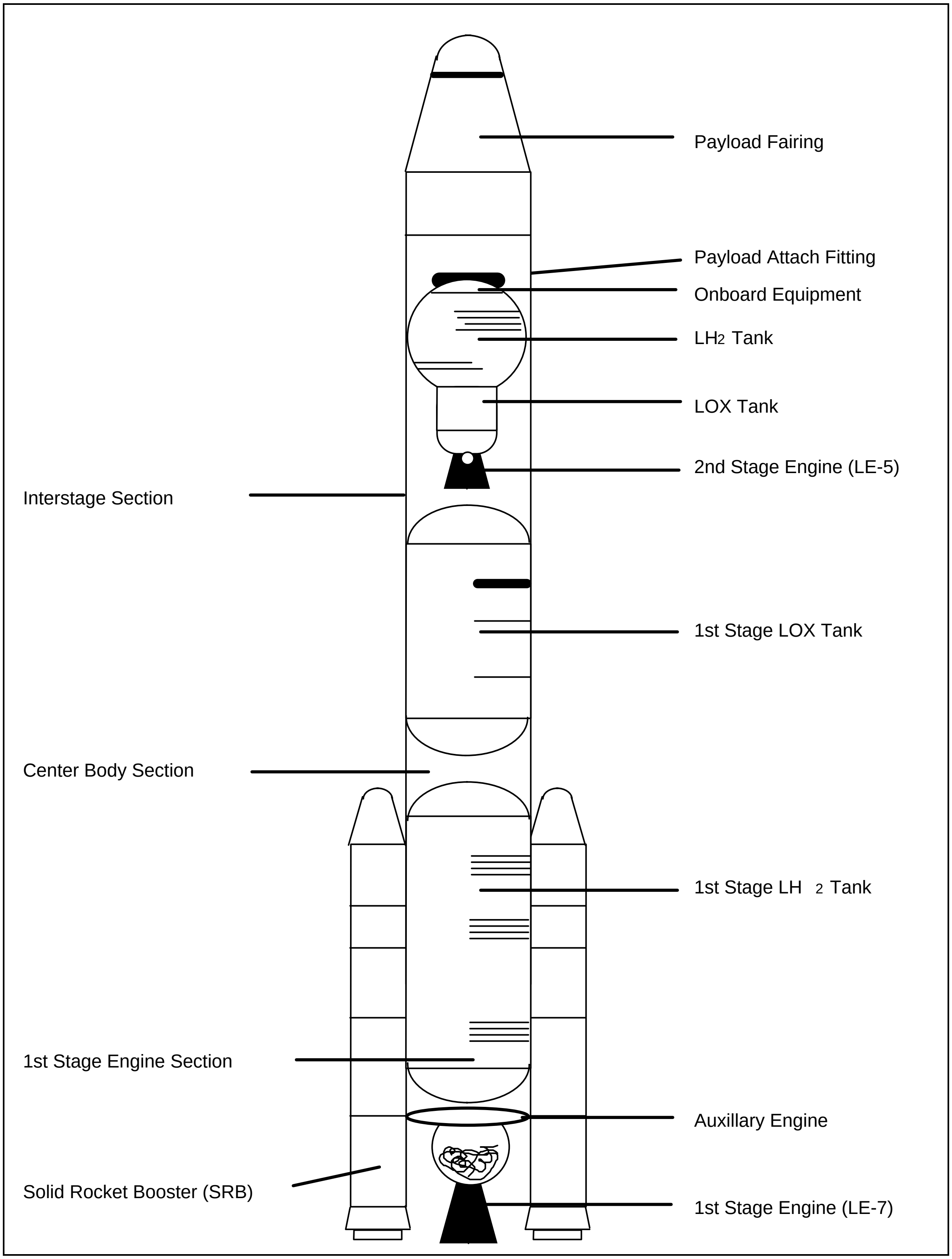

Figure 3.2-1 H-II Launch Vehicle

3.2.2 Launch Configuration

The current launch configuration of the TRMM communications system is such that both Transponders are switched to the Omni antennas. Transmitter-A will be powered ON upon upper fairing separation and will continuously radiate through the Omni antennas until commanded OFF. The appropriate rate index and filter tables will be selected to ensure proper downlink telemetry rates (1 Kbps of fill data on the I-Channel and 1 Kbps of housekeeping data on the Q-Channel) during initial acquisition. In addition, the Spacecraft Power Switching and Distribution Unit - A (SPSDU-A) Automatic Sequencer is ENABLED and SPSDU-B DISABLED for launch.

All ACS sensor hardware components and electronics (including primary and redundant sets) are powered ON at launch except for the four Reaction Wheel Assemblies/Electronics and the Engine Valve Driver (EVD). The ACS software will be configured in the Standby mode, and the ACE software (both ACE A and B) will be configured for normal operations. ACE A will be "in control" and will be receiving the "I'm Okay" signal from the ACS Processor (as a zero actuator command) to prevent the ACE from entering Safe-Hold. In this mode, most Fault Detection and Correction (FDC) checks are DISABLED. Both PSIB A and B will be powered ON, and all Deployable and instrument components/electronics are powered OFF. Final spacecraft launch configuration will be verified as part of the launch rehearsal. Automated telemetry checks will be performed using previously defined STOL procedures in the MOC. Table 3.2-2 provides the TRMM spacecraft launch configuration, by subsystem.

3.2.3 Launch and Ascent Timeline

As stated, TRMM will be launched on-board a NASDA provided H-II ELV. The launch time is currently scheduled to occur at between 5:40 AM and 7:40 AM (Japan), and the estimated separation time is 14 minutes and 6.5 seconds afterwards (approximately 839 seconds after launch). During ascent, the TRMM spacecraft will not be radiating, and TRMM real-time telemetry will not be available until after separation from the launch vehicle. Table 3.2-3 provides the launch and ascent timeline for TRMM and the H-II launch vehicle.

At separation, the TRMM spacecraft will be configured to establish both forward and return S-band Single Access (SSA) communications links with the TDRS-West (TDW) spacecraft. The nominal Omni command and telemetry rates are 500 bps and 1 Kbps, respectively. The initial communications link will be non-coherent with Doppler compensation ENABLED. This configuration allows TDRS to easily lock onto the TRMM Receiver. The 1 Kbps Omni telemetry downlink is on the Q-Channel with 1 Kbps of fill packets on the I-Channel. Using real-time telemetry from this initial contact, the Project, FOT, FDF, and ACS engineers will monitor the spacecraft attitude after separation.

Component	State	Comments
C&DH		
ACS Processors	ON	Prime ACS in Standby mode, and Backup ACS processor OFF. Despite the fact that the ACS software is in the Standby mode, the software will still be providing the "I'm Okay" signal to the ACE (as a zero actuator command) to prevent the ACE from entering Safe-Hold. The ACS software will sense the RWA power ON and autonomously transitions to the Sun Acquire Mode (and the separation counter=0). The wheels will not saturate for high rates because a "zero torque" command will be sent for high momentum.
Bulk Memory	ON	All bulk memory is allocated to the housekeeping and events recorders, until the instruments are powered ON.
Clock Cards Frequency Standards	ON	Clock card A and Frequency Standard A are powered ON at launch, and Clock card B and Frequency Standard B are OFF.
Downlink Cards	ON	Downlink card A will be powered ON at launch, and configured for communications through both transponders from SDS-A. Downlink Card B will be powered OFF.
SC Processors	ON	Side-A components are powered ON. The Side-A Uplink and Downlink card is configured to XP-A. RTS SCSEP will be activated upon separation to shadow the SPSDU Sequencer. In addition, the RTS will turn on transmitter A after fairing separation. The backup processor will be powered OFF.
Uplink Cards	ON	Both Uplink cards are powered ON at launch.
ACS		
ACE	ON	Both ACEs are powered ON. The ACE software (for both ACE A and B) is configured for normal operations, and not Safe-Hold. ACE A will be "in control" and will be receiving the "zero actuator" commands from the ACS processor.
Coarse Sun Sensors	ON	The CSSs on the -Y Solar Array are the prime sensors for the ACS to perform Sun Acquisition. The +Y CSSs serve as a backup.
Digital Sun Sensors	ON	The DSSs provide Sun presence, elevation, and azimuth information used for yaw reference.
Earth Sensor Assembly	ON	The ESAs are used to perform Earth Acquisition.
Engine Valve Driver	OFF	The EVD is the interface between the ACE and the RCS thrusters, and will not be utilized unless thrusters are required.

IRUs (Gyros)	ON	The Gyros sense the spacecraft's angular rates, which are used for rate damping and for attitude information (yaw axis).
Magnetic Torquer Bars	ON	The MTBs are used to reduce spacecraft momentum, including those induced by high tip off rates.

Table 3.2-2 Launch Configuration

Component	State	Comments
Reaction Wheels	OFF	The RWAs will be powered ON by the sequencer immediately after all SA and HGA Pyro firing commands have been issued (90 seconds after separation). The RWAs will not be utilized until spacecraft momentum is reduced (using the torquer bars) below a certain level.
TAMs	ON	The TAMs sense the direction and strength of the Earth's magnetic field. This information, along with the reaction wheel speeds, will be used to drive the magnetic torquer bars to react against the Earth's magnetic field to unload excess system momentum.
POWER		
PBIU	ON	The PBIU is powered ON and operating.
PSIB	ON	Both PSIB A and B (no telemetry via B) is powered ON and operating nominally. Low Power detection and automatic non-essential bus shutdown is Enabled (although all items on the non-essential bus are already powered OFF at launch).
Solar Arrays	STOWED	The SAs will be deployed, along with the HGA, 60 seconds after separation by the SPSDU-A sequencer.
SPRU	ON	The SPRU is powered ON at launch and configured in the Standby mode. After successful capture of the Sun (by the CSSs), and Power is applied to the system, the SPRU will autonomously switch to the Peak Power Tracking mode.
ELECTRICAL		
IPSDU		Both IPSDU A and B are powered ON. The Solar array deployment monitor on IPSDU A is set to trigger the GSACE on positive indication of +Y solar array deployment.
SPSDU	ON	SPSDU A and B are both powered ON, with the Launch sequencer running on SPSDU B.
RF		
Omni Antennas	N/A	Configured to both Uplink and Downlink cards. Configured in the 1 Kbps data rate and in the TDRS mode.

Power Amplifier	ON	PA is powered ON and in the Standby mode.
RF Switches	N/A	RF Switch 1 is configured in the Normal configuration, RF Switch 2 is configured in the reverse configuration, and RF Switches 3 and 4 are configured to the Omni antennas. Prior to utilization of the HGA, Switch 3 must be configured to the HGA, to communicate via Transponder A.
Transponders	ON	Transponder A and B are powered ON. Both transponders are configured for uplink at 500 bps via the Omni antenna. Both transmitters are powered OFF. Transmitter A will be powered ON upon fairing separation. Both receivers are powered ON at Launch.

Table 3.2-2 Launch Configuration (Continued)

Component	State	Comments
THERMAL		
Non-operational (Survival) Heaters	ON	Survival Heaters are powered ON at launch, and will operate autonomously as required (thermostatically controlled).
RCS		
Catalyst Bed Heaters	OFF	The Catalyst Bed Heaters will not be powered until required to perform the orbit descent maneuver, unless the RCS is required to reduce system momentum (due to excessive tip-off rates or a spacecraft anomaly).
PCM & Pyro Valves	OPEN/ CLOSED	The thruster isolation valve will be OPEN, but the tank isolation valve and thruster valves will be CLOSED.
Thrusters	DSBL	Thrusters will be Disabled at launch. Barring any unforeseen anomalies, the Thrusters will not be utilized during the initial spacecraft checkout. The Thrusters are not required until either the Orbit descent maneuver (down to 350 km) or the first Delta-V maneuver. However, the ACS/RCS may elect to calibrate the Thrusters prior to actual usage.
DEPLOYABLES		
GSACE	ON	GSACE A is powered ON (the DCM and logic board ONLY). The +Y and -Y solar array motor drivers are disabled. The Sequencer for GSACE A is Enabled.
HGA	STOWED	The solar arrays will be deployed, along with the HGA, 62 seconds after separation. Separation will initiated by the sequencer.
HGAD/PS	STOWED	Stowed at launch, the HGAD/PS will be deployed, by the sequencer, after separation from the H-II.

SADAs	OFF	Stationary at launch, the +Y SADA will be rotated to the Index position by the Sequencer after completion of Solar Array deployment.
INSTRUMENTS		
PR	OFF	The PR Instrument is OFF, with the survival heaters (only 1-side) ON (thermostatically controlled).
VIRS	OFF	All doors are closed with the survival heaters ON (thermostatically controlled), and power is applied to the Shutter. Shutter is Closed.
TMI	OFF	The TMI instrument is stowed for launch. The sensor then the Antenna will be deployed after successful spacecraft checkout. The survival heaters are ON (thermostatically controlled).
CERES	OFF	The CERES Instrument is OFF, with the azimuth gimbal caged, the elevation gimbal stowed, contamination covers CLOSED, and the survival heaters, thermostatically controlled and scan head strip heaters, are ON .
LIS	OFF	The LIS Instrument is OFF, with the survival heaters ON (thermostatically controlled).

Table 3.2-2 Launch Configuration (Continued)

Time (hh:mm:ss)	H-II Launch Vehicle	TRMM Spacecraft
Pre-Launch		S/C configured for Launch
L - 00:00:02	First Stage Engine Ignition	
L - 00:00:00.300	SRB Ignition	
Launch (L)	Liftoff	
L + 00:01:34.2	SRB Burnout	
L + 00:01:37.1	SRB Separation	
L + 00:03:45	Fairing Jettison	
L + 00:05:45.1	First Stage Main Engine Cutoff (MECO)	
L + 00:05:54.2	First Stage Separation	
L + 00:06:00.2	Second Stage Engine Ignition	
L + 00:13:29.6	Second Engine Cutoff - 1 (SECO-1)	
L + 00:14:05.0	TRMM Separation	
L + TBD	Avoidance maneuver	

Table 3.2-3 Launch and Ascent Timeline

3.2.3.1 Launch Sequence

There are currently three main events used to trigger spacecraft activities during the launch sequence. These events are defined as Fairing Separation, Spacecraft Separation, and +Y Solar Array Deployment. These three events are defined as follows:

a. <u>Fairing Separation</u>
Upon detection of separation from the H-II fairing, the Pyro Initiation Module (PIM) within the SPSDU is Enabled to allow Pyro firings. Additionally, upon detection of fairing separation within the Divisible-bus Control Module (DCM), telemetry from both SPSDUs and the spacecraft processor will activate a "fairing separation" command sequence (RTS). This RTS will be used to turn ON transmitter A (TBC by NASDA).

b. <u>Spacecraft Separation</u>
The SPSDU sequencer will be activated upon detection of spacecraft separation, as indicated by the separation switches. The sequencer will Arm, Enable, and Fire the appropriate Pyros required to deploy the +Y Solar Array (A, B, C, D, and E release mechanisms), -Y Solar Array (A, B, C, D, and E release mechanisms), HGADS A and B release mechanisms, and then Close the appropriate relays to apply power to the Reaction Wheels (in that order). The FDS software will also monitor the separation switches in the SPSDU telemetry. Upon detection (from either SPSDU) of separation, the FDS software will activate the "separation enable" RTS (SEPENABLE), which enables the launch RTSs. The launch RTSs include the "spacecraft separation" RTS (SCSEP) and the "+Y SA Indexing" RTS (SAPLUS). Two seconds after the SEPENABLE RTS has been executed, the SCSEP RTS is activated. This command sequence

will shadow the SPSDU sequencer (issue the same commands as a backup), and turn ON transmitter A (back-up to fairing monitor).

c. Solar Array Deployment

Upon detection of successful deployment of the +Y SA, via potentiometers, the IPSDU Thermistor Monitoring Module (TMM) will activate the sequencer within the GSACE. The GSACE sequencer will initialize the Solar Array Module (+Y axis). In addition to the GSACE sequencer, the FDS will also monitor the three +Y solar array potentiometers from the IPSDU telemetry. Upon detection of solar array deployment, the FDS will backup the GSACE sequencer by activating the +Y Solar Array Indexing RTS (SAPLUS).

3.2.4 In-Orbit Initial Checkout

Once successful RF communications has been established with the spacecraft, a thorough analysis will be performed to determine the success of launch. S/C housekeeping data will be captured and processed after separation from the H-II. From these data the MOC systems will produce R/T plots, statistics files, and archive files for data analysis. The history files and all off-line data during this phase will be stored in the MOC for the remainder of the mission. Once the TRMM is acquired through TDRS, the health and status of the spacecraft will be assessed. After the health and status of TRMM is verified, a series of spacecraft activities will be performed to checkout the spacecraft. After initial checkout, the spacecraft will be configured for the engineering mode, at which time the instruments will be powered ON for checkout and calibration activities. Table 3.2-4 provides a detailed timeline for the initial in-orbit checkout of TRMM.

Once the -Y solar array is successfully deployed, the FDS TMM will initiate the RTS called SAMINUS. This RTS will set the ACS down counter to zero. When this down counter is zero and when the ACS software detects the four reaction wheels are powered ON, the ACS will autonomously transition to Sun Acquisition control mode. If the SA are not in index position already, the ACS software will command the GSACE to do so. In addition, the ACS auto selects a CSS set to use and proceeds to reorient the spacecraft's +X body axis to 16.5°± 10° of the Sunline. This is the TRMM Power- and Thermal-safe attitude.

Based upon the injection vector, provided by NASDA, the FDF will provide the MOC with an updated TRMM EPV file. After EPV load generation is complete, the selected TRMM EPV will be uplinked for use by the ACS orbit propagation algorithm. When the epoch of the uplinked EPV occurs, the ACS engineers will verify the proper acceptance and use of the vector by the ACS software.

Prior to using the HGA for communications, dummy HGA tracks will be performed . Once software is monitored and verified, HGA control will be Enabled. Following completion of spacecraft checkout, the HGA will be used for nominal TDRS communications.

The ACS Engineers will evaluate the overall performance of the system. Upon their approval, a real-time command will be transmitted to transition to Earth Acquisition mode. After the Earth

Sensor Assembly (ESA) locks onto the Earth, autonomous transition to Yaw Acquisition mode will occur.

Time (Seconds)	Activity	Description
Separation (S)		
S + 15 L + 1015	Initial RF Communications	Turn ON transmitter and acquire TDRS West (1 Kbps return, 500 bps Command, Omni RHCP, Non- coherent, Doppler Compensation ENABLED).
S + 60 L + 1060	HGA & SA Deployment	PSDU B sequencer is activated, firing A and B Pyros to deploy SAs and HGA.
S + 90 L + 1090	RWAs Enabled and Powered ON	Reaction Wheels Enabled and Powered ON (2 second intervals).
S + 100 L + 1100	Sun Acquisition	ACS processor enters Sun acquisition mode using Gyros for Rate nulling.
S + 120 L + 1120 - 1180	Solar Array Deployment Complete	ACS processor in Sun acquisition mode using -Y CSSs for attitude control
S + 180 L + 1180	+ Y SA Indexed	GSACE sequencer issues command to index +Y SA.
S + 200 L + 1200	SPRU Peak Power Tracking Mode	SPRU begins to Peak Power Track SA current.
S + 15000 L + 16000 [1]	Sun Acquisition Complete	ACS successfully acquires the Sun. Set TRMM EPV, Establish high rate telemetry.
S + TBD	Earth Acquisition	ACS performs Earth acquisition (ground command required).
S + TBD	Yaw Acquisition	ACS performs Yaw acquisition, autonomously upon completion of Earth Acquisition. Upon completion, the ACS will autonomously transition to Mission mode.
S + TBD	Engineering Mode	Spacecraft enters Engineering Mode

1 Time will depend on severity of the tip-off rates. 11,000 seconds is the time required for acquisition for 3-sigma tip-off rates.

Table 3.2-4 Initial In-orbit Spacecraft Checkout Timeline

3.3 NORMAL MISSION OPERATIONS

Normal Mission operations consists of maintaining spacecraft and instrument health and safety, providing routine control of the spacecraft and instrument systems, and collecting science data. The FOT is responsible for monitoring observatory health and safety and providing routine spacecraft control. The science facilities are responsible for ensuring that science objectives are met and for monitoring and maintaining instrument performance. The FOT will ensure safe observatory operations from the Mission Operations Center (MOC).

Normal Mission operations can be described in terms of the chronological order in which activities occur. The various activities that are conducted in support of TRMM operations can be thought of in terms of mission planning and scheduling, real-time operations, trend and performance analysis, and data archiving. Coordination and cooperation between the FOT, instrumenters, and supporting ground elements is essential.

3.3.1 Mission Planning and Scheduling Overview

Mission planning and scheduling covers those activities conducted to prepare for daily operations. The TSDIS SOCC will assist with the planning and scheduling operations for the three rain instruments (PR, TMI, VIRS). The FOT will provide planning and scheduling of CERES and LIS activities, for the LaRC and MSFC instrument facilities. The time period for planning begins approximately one month before a given week's operations. Ultimately, observatory planning results in the generation of a Daily Activity Plan (DAP). This plan contains the observatory commands required for a single day's operations. A more detailed description of the instrument mission planning process is provided in Section 7.1.1.

Once a DAP is generated and a confirmed TDRS schedule from the NCC are in the MOC, constraint checking, modeling, and load generation for a given day's operations can begin.

Another major activity conducted in preparation for TRMM operations is SN contact scheduling. This process begins approximately three weeks prior to the operational period when orbital data products are received from the FDF. The FOT's interface with the NCC is via the User Planning System (UPS), which provides automated schedule generation and electronic communications for exchanging TDRS schedule requests and confirmed schedules. Additional details regarding the TDRS scheduling process are provided in Section 7.3.

3.3.2 Real-time Operations Overview

Real-time operations consists of health and safety monitoring, routine commanding, spacecraft stored command processor loading, solid state recorder management and data capture. In general, the FOT is responsible for maintaining and establishing communications with the spacecraft, accomplishing stored command loads, uplinking extended precision vectors (EPVs), and responding to changes in planned operations and observatory status. The science facilities are responsible for long-term instrument health and performance monitoring, and science data processing. Real-time activities are discussed extensively in Section 6.0, and instrument operations are discussed in Section 5.0.

3.3.3 Performance Analysis and Data Archiving

FOT responsibilities for observatory health and safety include performance and trend analysis using the Generic Trend Analysis System (GTAS). Level-0 data files from the SDPF, which contain merged real-time and playback housekeeping data, are used for this process, which is discussed in more detail in Section 7.4. The purpose of long-term trending is to identify potential problems and develop appropriate responses before irreparable degradation occurs. The GTAS can also be used to assist in anomaly investigations by reprocessing archived telemetry files. In this context, the goal is to identify possible causes for a given situation.

Archival of certain information is required to assist in the analysis process. Key items requiring archival include Level-0 telemetry files and various history files created by the MOC. Some history files, such as command history and integrated print reports, are archived for the life of the mission. Other files that are useful for establishing the context for the day's activities are stored for shorter durations. The GTAS end-to-end data flow is illustrated in Figure 3.3-1

3.3.4 24-Hour Operations Profile

FOT personnel are responsible for mission planning, operations coordination with other facilities as required, anomaly investigations, routine status reporting, and trend and performance analysis. A brief overview of daily real-time operations activities is discussed below.

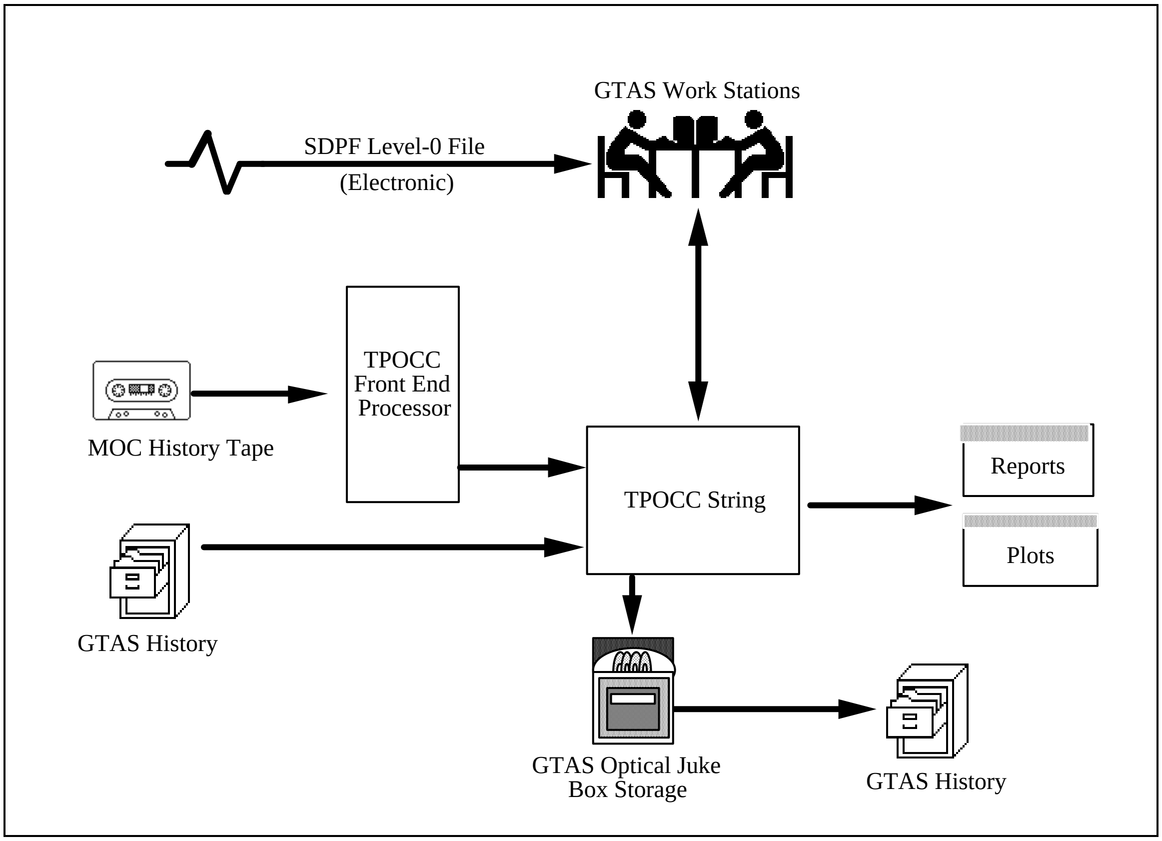

Figure 3.3-1 GTAS Data Flow

The TRMM will communicate to the ground system through the TDRS network SSA antenna. During typical TDRS SSA events, both forward and return services are scheduled. Nominally the FOT will schedule a coherent event once per orbit. Due to the frequencies utilized by TRMM, TDRS Multiple Access (MA) services will not be available.

During real-time events, the FOT monitors the health and safety of the observatory via the housekeeping telemetry stream downlinked on VC 0. All recorded data is telemetered from the Solid State Recorder (SSR) on VCs 1 through 6. The MOC does not process science data, but will account for its capture from the S/C to the ground. During real-time events, forward and return services are scheduled for 20 minutes every orbit to accomplish SSR playbacks. Ranging data will also be provided to the FDF for orbit determination and will be used by the FOT for clock correlation activities. Figure 3.3-2 and 3.3-3 illustrate the TRMM 24-hour mission profile for the space and ground segments, respectively.

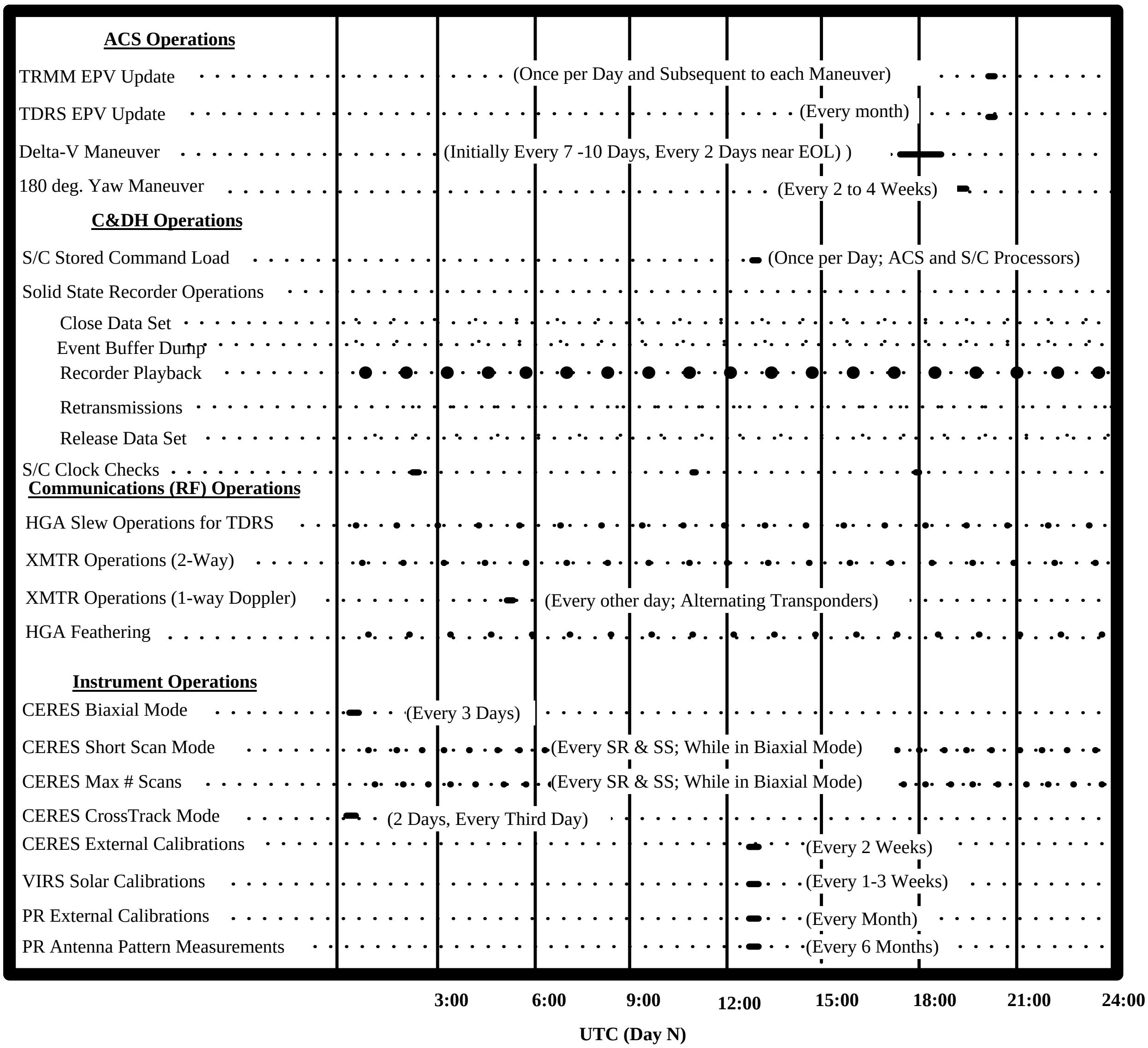

Figure 3.3-2 24-Hour Operations Profile (Space Segment)

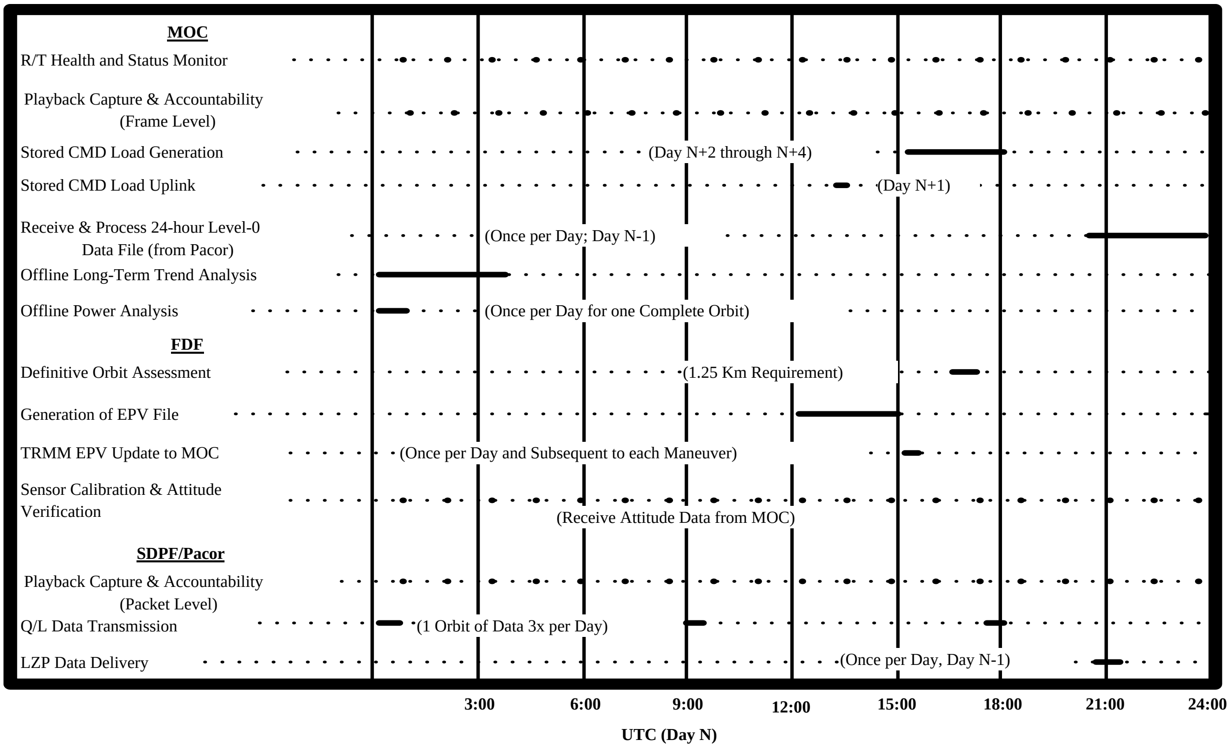

Figure 3.3-3 24-Hour Operations Profile (Ground Segment)

3.4 END OF LIFE OCEAN DISPOSAL

Due to the nature of the low Earth orbit, the TRMM spacecraft will require a safe End of Life (EOL) ocean disposal. Currently, 58 Kg of fuel has been budgeted to perform the EOL maneuvers required for ocean disposal. At the end of the mission (when it is determined that 58 Kg of fuel is remaining), the science mission will be terminated.

The EOL ocean disposal of TRMM shall be in accordance with the requirements stated in the NASA Handbook (NHB 1700.1). Magnetic torquer bars will be used to unload system momentum from nominal altitude, until the altitude reaches 270 km. The spacecraft altitude will then be allowed to decay to 200 km. The RCS will provide momentum unloading of the reaction wheels during the remainder of the descent to 200 km. The RCS shall support a final disposal maneuver (1 or 2 burns) to place the spacecraft into an elliptical orbit with a target perigee of 50 km.